Automated Robotic Manipulator System (ARMS)

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Abstract

The purpose of this project is to develop, build, and test the Automated Robotic Manipulating System (ARMS) prototype. The system is composed of two robotic manipulators mounted to a mobile base platform. Each manipulator is equipped with unique end-effectors, designed to capture and manipulate objects in space and to perform repairs to satellites. The completed system was tested on a micro-gravity simulation flat-floor in the Marshall Space Flight Center Flight Robotics Laboratory.

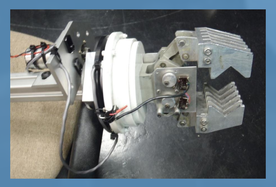
Background

Active space systems in orbit commonly require maintenance and expired systems often need to be recycled for parts when their purpose is fulfilled. Historically, satellite malfunctions that could not be fixed remotely were resolved via extra-vehicular activities performed by astronauts. Direct human interaction in the maintenance of space systems is often costly and dangerous, making robotic systems more advantageous for satellite maintenance.

Design Concept and Development

• **Design Concept:** two robotic manipulators mounted on a mobile base platform; two unique end effectors: one to grapple and hold target satellites while the other performs minor repairs.

•**Nine degrees of freedom (DOF):** Provided by four servos and five electric motors; four DOF on each arm, and a shared rotational DOF by a Lazy Suzan/motor system mounted to base.



• **Environmental requirements**: ability to operate in micro-gravity and vacuum, endure major temperature gradients, manipulate itself for tasks, and transmit data in low light conditions.

Connector plates were specifically designed and fabricated for mounting the servos, motors, and end effectors to ARMS' structure

Materials and Methods

• **Structure**: 80/20 brand aluminum was used to build ARMS, chosen for its strength to weight ratio and easy assembly. ARMS is affixed to plywood mounted to an aluminum mobile base.

• **Servos:** Six standard R/C servos with 845 oz-in holding torque

• **Motors:** Five motors each running between 0.5 to 2 Amps

• **Cameras**: Three cameras provide situational awareness to the operator. The cameras are autofocus, low lux camera with up to 27X zoom. All three are operated simultaneously using a video server.

•**Power:** Two 12 volt batteries supply power to the system. The necessary system power was calculated using the following equation:

$$P(t) = I(t) \bullet V(t)$$

• **Controllers:** An Xbox 360 gaming counsel controller provides an intuitive and user-friendly interface to manipulate ARMS

• **Software:** LabView was used to create a program to control motors and servos to move the degrees of freedoms

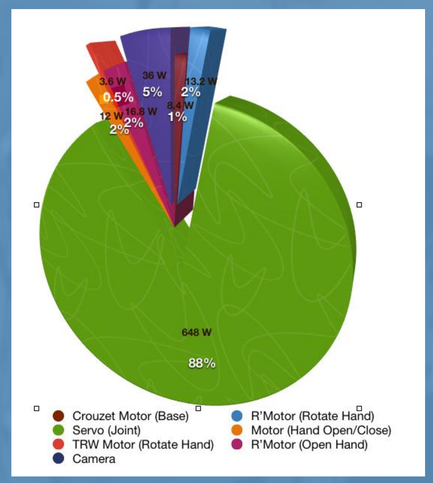
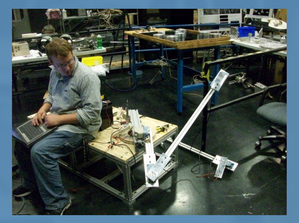
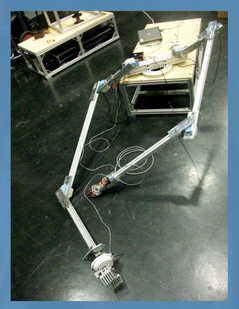


Figure 3: Graphic representation of power budget for the system

Results and Testing

The completed system was tested for compatibility in the space environment on a micro-gravity simulation flat-floor in the Flight Robotics Laboratory at Marshall Space Flight Center. Air bearings were attached to ARMS' mobile base to allow it to float on the flat-floor.





Factors evaluated during testing:

1. The ability of ARMS to support its own weight
2. Mobility and functionality of manipulators and their end-effectors
3. Reach for items within desired work envelope: 5" to 42"
4. Grab and hold target satellite
5. Perform basic repairs to target satellite
6. Test camera capabilities in space-like lighting conditions

Figure 1: Picture of completed ARMS

Conclusions and Future Work

Robotic manipulators, such as ARMS, are necessary for use in future space missions, as they provide a safe, cost-effective method for capturing and repairing satellites.

Future Work:

1. Attach ARMS to a "smart" mobile base that is able to autonomously navigate to satellites
2. Communicate between interfaces via wireless connections
3. Interface with the robotic manipulators using virtual human technology
4. Create additional detachable tools for ARMS that can execute basic repairs on satellites

Acknowledgements

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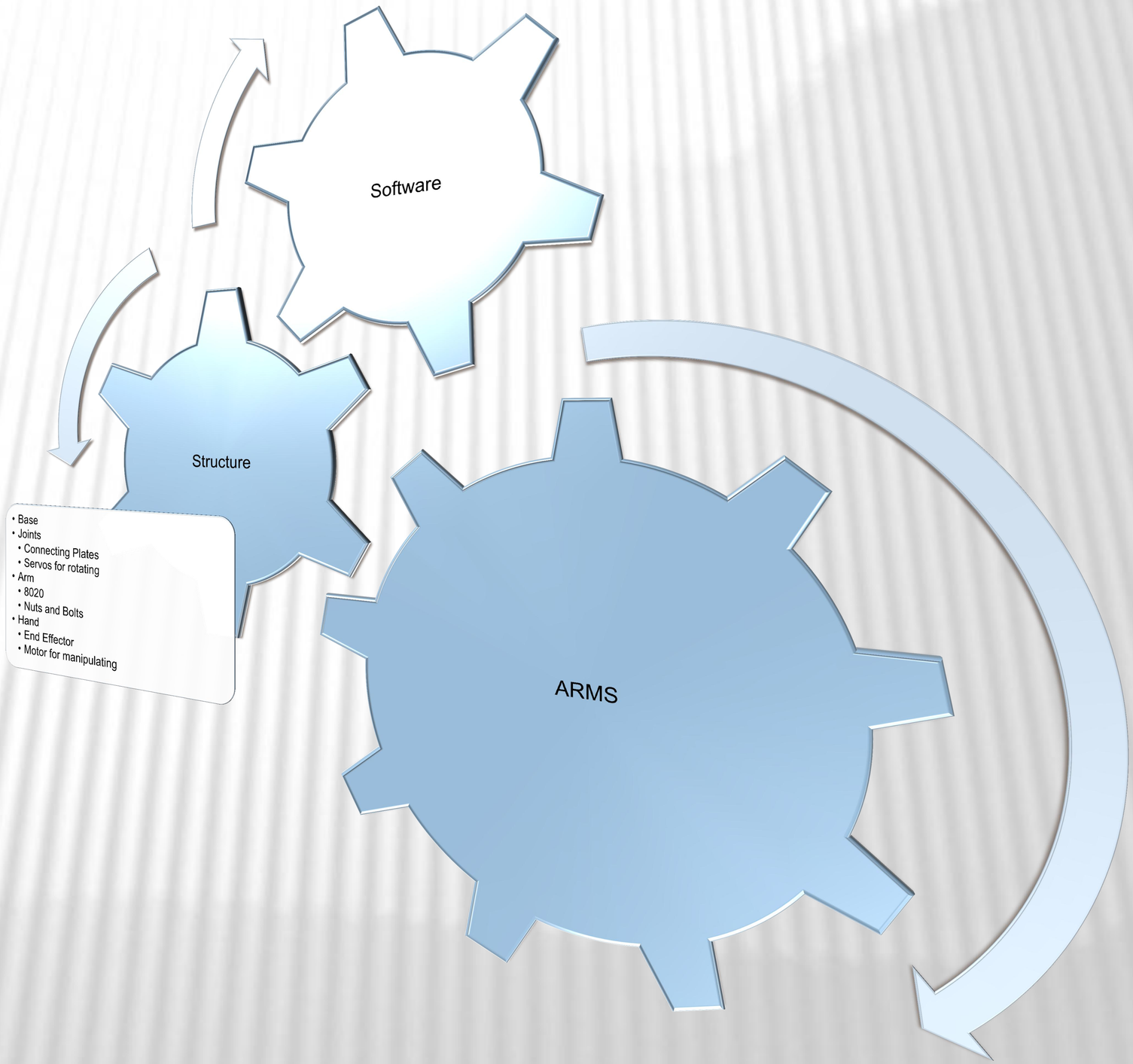
Software
Structure
• Base
• Joints
• Connecting Plates
• Servos for rotating
• Arm
• 8020
• Nuts and Bolts
• Hand
• End Effector
• Motor for manipulating
ARMS